A User-Centred Personalised e-Learning System

Thao Nguyen
Vanessa Chang

School of Information Systems

Curtin University of Technology

Perth, Australia

Email: thao.nguyen@cbs.curtin.edu.au
vanessa.chang@cbs.curtin.edu.au

Abstract

The paper proposes a framework for understanding the factors that affect usability of e-learning. The framework can be applied to the development of (1) a formative usability evaluation method for e-learning systems and (2) personalisation rules for e-learning systems interface. The formative usability evaluation method is intended for the evaluation of e-learning systems during its development stages, from screen-based prototypes to near completion. The evaluation criteria will be customisable depending on contingent criteria such as user characteristics and e-learning system characteristics. A web-based prototype will be developed to allow the convenient implementation of the methodology. The personalisation rules for e-learning system is intended for the automatic adaptation of e-learning systems' interface to different users' preferences in order to maximise its usability and learnability for individual users.

Keywords

E-learning system usability, e-learning usability, usability evaluation of e-learning system, heuristics evaluation, e-learning system, personalised e-learning.

INTRODUCTION

E-learning systems include the application and learning materials that support e-learning such as educational websites, Learning Management System and intelligent tutoring systems. These can be off-the-shelf software packages such as Blackboard and WebCT, or custom-built e-learning systems such as InterLearn (Bonk 2000).

Due to the remote nature of e-learning, it is essential that the e-learning system is usable. However, there has been little research in the area of e-learning usability (Kukulska-Hulme & Shield, 2004; Nokelainen 2004a). Additionally, studies have emphasised on the importance of incorporating users' perspective into the design of the e-learning systems (Koohang 2004b). Most current methodologies tend to focus on summative rather than formative usability evaluation (Elissavet and Economides, 2003, Nokelainen, 2004b). Formative usability evaluation is conducted during the development process of the product for the purpose of identifying defects and making improvements to the product, while summative usability evaluation is conducted on completed systems, generally for quality control and selection (Nielsen 1993). There is a need for a formative usability evaluation methodology that evaluates both the traditional usability and the pedagogical aspect of e-learning systems.

The aim of this research is to develop a framework to understand the factors affecting usability of e-learning systems. This is achieved by focusing on the following two factors which support a formative usability evaluation of the e-learning system:

- Heuristic-based formative usability evaluation of e-learning system from the learners' perspective
- Personalisation rules for e-learning systems interface.

Heuristic evaluation is an expert-based formative evaluation method developed by Nielsen and Molich (1990) which can be done at any stage of the design cycle. The strength of this method lies in its cost-effectiveness and proven ability to capture a substantial number of interface usability problems (Nielsen and Phillips 1993).

CURRENT UNDERSTANDING OF E-LEARNING SYSTEM USABILITY

To design usable interface it is important to first understand what makes an e-learning system usable for learners. A number of authors have looked into the usability factors affecting e-learning. Several recent attempts have been made to modify factors used for website usability so that they suit e-learning system (Grani, et al. 2004; Triacca, et al 2004).

Several authors have recognised that modifying existing usability criteria for traditional or online application will not suffice (Ghaoui 2003), (Kukulska-Hulme and Shield 2004), (Nokelainen 2004a), (Silius et al 2003). E-learning requires pedagogical criteria in addition to existing usability criteria. Reeves (1997) proposed 14 pedagogical dimensions for evaluating e-learning software. He recommended a set of heuristics and a protocol for heuristics evaluation of e-learning programs that are valuable for developing the pedagogical usability criteria affecting e-learning. However, these criteria need to be validated for its relevance to e-learning as they were generated from instructional designers and lecturers without inputs or validation from the users' perspective (Reeves et al 2002).

A FRAMEWORK FOR UNDERSTANDING USABILITY FACTORS AFFECTING E-LEARNING SYSTEM

As indicated before, it is the aim of this research to incorporate heuristic evaluation and personalisation rules in order to address the efficacy of e-learning systems. The aim of this section is to explain the components of the framework required to develop the evaluation tool. An extensive literature search was carried out to ensure that the model is comprehensive. The conceptual model to support the above rationale is adapted from Gerhardt-Powals (1996), Reeves (1997), Kennedy et al (1998), Kirakowski et al (1998), Najjar (2001), Reeves, et al (2002) and Turk (2001) and illustrated in Figure 1. The following sub-sections provide an explanation of each of the component in the model (see Figure 1).

Component 1: Usability Factors (Characteristics of the E-learning System)

These usability factors are the characteristics of the system that have an impact on how the e-learning system is used. The ideal e-learning system usability factors include (1) the usability factors affecting e-learning applications (Gerhardt-Powals, 1996; Kirakowski et al, 1998; Turk, 2001) (2) the usability factors affecting multimedia applications ([Kennedy et al, 1998; Najjar, 2001), and (3) the usability factors affecting the learning process (Govindasamy, 2002; Nokelainen, 2005; Reeves, 1997; Reeves et al, 2002; Silius, et al, 2003)

The list of usability factors to be investigated in this research as adapted from the above-mentioned authors includes:

- *Interface issues*: The characteristics of the e-learning systems' interface that have an effect on its usability. The interface issues may include factors such as attractiveness, consistency, customisability, error reduction/recovery, help and documentation, internationalisation, learner control, recall and recognition improvement, navigation support, and interactivity.
- *Pedagogical issues*: The characteristics of the e-learning system that facilitate learning. The pedagogical issues may include learner control, learner activity, applicability, added value for learning, motivation, valuation of previous knowledge, and flexibility.

- *Information architecture issues:* The characteristics in the structure of the information that have an effect on usability. These include presentation, names and information organisation, sequencing of information, and search facility.
- *Accessibility/delivery issues*: The technical issues relating to the accessibility and delivery of the information. These include accessibility, download speed, adherence to conventions, and standards.
- *Multimedia issues*: The characteristics of the multimedia elements of the e-learning system that affect its usability. These include coherence of multimedia presentation, suitability of the multimedia used, use of elaborative media, and synchronicity of multimedia presentation.

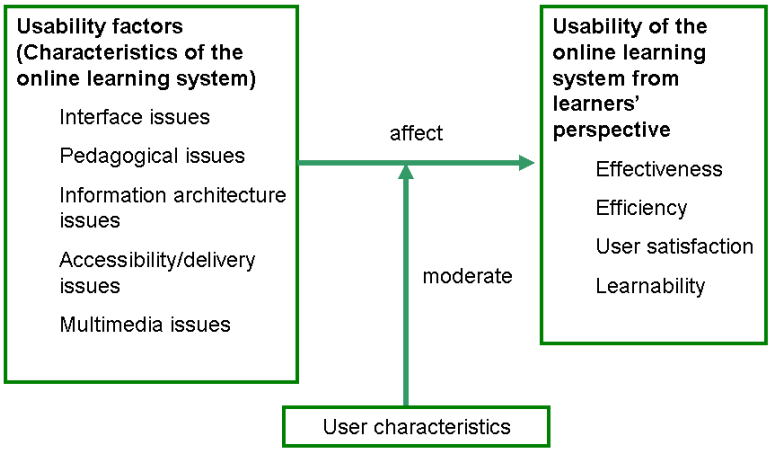

Figure 1: Conceptual Framework for Understanding Usability Factors Affecting Online learners

Component 2: Usability of the E-learning System from Learners' Perspective

E-learning system usability can be defined as the extent to which the e-learning system enables its users to achieve the learning tasks effectively and efficiently within a reasonable amount of time (Rentroia-Bonito et al 2003). Usability attributes are the outcomes of the interaction between the user and a usable e-learning system ([Koohang 2004b). These traditionally include the subjective item of *user satisfaction* and objective items including *effectiveness* and *efficiency* (Nielsen, 1993, Shackel, 1981). *Learnability* has been added to represent the pedagogical issues that are pertinent to a useful e-learning system (Silius, et al, 2003).

Component 3: User Characteristics - The Modifying Factors

Modifying factors are the users' characteristics that may influence the outcome of the interaction between the user and the system. Prior research suggested that a learner's characteristics such as prior experience with the Internet and computer, cognitive style, and culture may affect his or her importance rating of certain usability factors affecting an e-learning system (Koohang, 2004a; Turk 2001; Webster 2002). Additionally, the type of the e-learning system, most notably its pedagogy, may also be a relevant modifying criterion. Cognitive style can be defined as an individual's information representing and processing preferences (Riding & Rayner, 1998) as cited in Webster (2002). Cognitive style can be defined by two dimensions: verbal-imaginary and wholist-analytic (Riding and Cheema, 1991) as cited in Webster (2002). Cognitive style was found in Webster's study to be useful and relevant to the design of interface and content of e-learning environment. Culture could be provisionally defined along the dimensions proposed by Hofstede (1986). The pedagogy of e-learning systems could be defined along the line of learner-centred versus teacher-centred; and learning-by-doing versus didactic systems.

Empirical Evaluation of the Factors

A survey will be conducted to investigate (1) the relevance of the usability factors identified from the existing literature when applied to e-learning system usability, (2) the importance rating of the factors,

and (3) the moderating criteria that may affect the importance rating of the factors. It is anticipated that this model will be tested with e-learning systems used in higher education.

DEVELOPMENT OF A HEURISTIC-BASED METHODOLOGY FOR FORMATIVE USABILITY EVALUATION OF E-LEARNING SYSTEM

At the heart of the methodology there will be a heuristic-based set of questions that can be used to evaluate e-learning systems. The methodology is "contingent". That is, the methodology will include rules for customising the set of evaluation questions for different situation as this is expected to optimise the use of resources. The methodology is intended to evaluate e-learning systems during its development stages, from screen-based prototypes to near completion.

The methodology will be developed in four steps.

Step 1: Develop a bank of usability evaluation questions that address the usability factors that are validated in the survey mentioned above. Each factor might require two or more questions.

Step 2: Define the contingent rules based on the validated contingent criteria. The contingent rules will be used to customise the usability evaluation questions for specific situations.

Step 3: Define the guidelines for conducting the usability evaluation.

Step 4: Define the guidelines for reporting the usability defects and recommendations for improvement.

The Prototype

The methodology will be implemented in an online prototype that semi-automates the formative evaluation process. The prototype as illustrated in Figure 2 will be available online and include: (a) three databases that store the customisation rules, the evaluation questions and the defects and recommendations; and (b) three interfaces for collecting inputs from users and presenting evaluation results.

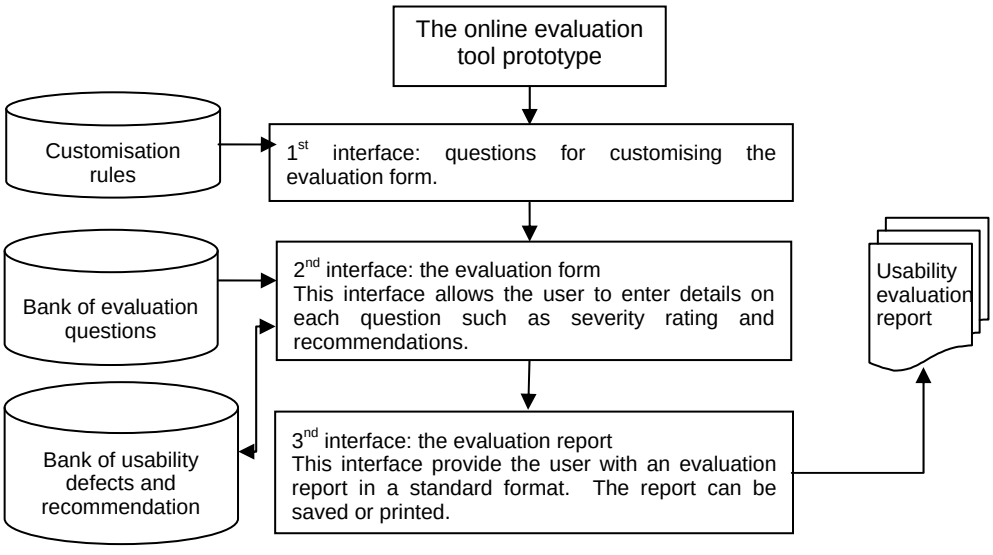

Figure 2: Components of the Online Evaluation Tool Prototype

At the beginning of the evaluation process as shown in Figure 2, the evaluator goes on the online prototype and answers a number of questions relating to the target learners and the pedagogy of learning material. Based on the answers, the system will present the user with an evaluation form. This form includes evaluation questions that are selected based on the customisation rules. The customisation rules are created based on the modifying criteria as explained in the previous section and illustrated in Figure 1, that are empirically evaluated to be relevant and significant and its

relationships with the usability factors. The aim of the customisation rules is to reduce the number of evaluation questions down to the ones that are relevant for the particular group of target learners and the type of the e-learning system.

The evaluation questions are created based on the usability factors that are empirically evaluated to be important and relevant to learners. It will be presented in a format that allows the evaluator to enter the usability defects and recommendations into the system. Once all the questions have been addressed, the evaluator will access a reporting screen. At this stage the system does two tasks: (a) saves the defects and recommendations to a bank of recommendations for future reference. Eventually, this bank could also be built up to be a knowledge base that allows automated generation of recommendations; and (b) shows the evaluator the report in a standard format and allows the report to be saved or printed.

Value of the Prototype

This evaluation prototype is useful for the following reasons. Before any e-learning system is created, it is tested formatively with the target learners. The rapid prototype creates an early iteration and intervention that provides valuable feedback on usability issues, creative treatment, and effectiveness of instruction. The report from the prototype provides valuable insights and allows the evaluator to reflect on the feedback. In some cases, a new prototype may be developed for subsequent testing of any further refinements.

The prototype overcomes the limitations of traditional e-learning development approach in that it enables the content providers, instructional designers and learners to integrate formative evaluation. This formative review process is critical in today's e-learning system development in that it can capture early defects, as well as identify user characteristics. This is significant in that the e-learning system is able to deliver individualised or personalised learning in accordance with pedagogic aspects.

A Personalised Interface for E-learning Systems

Over a period of time, a database of the user characteristics and the corresponding preferences will allow for the automatic generation and recommendations of the design features of an e-learning system. For example, students of a certain learning style might prefer a lot more contents, while students of other style might prefer interactive exercises. Some students might prefer online messaging or chat as interactive tool, while others might prefer communicating with each other through synchronous tools or emails. This database is derived from the usability factors (the characteristics of the system) and the user characteristics that have a modifying influence on usability of the system.

When a user opens the e-learning system for the first time, he or she will be presented with a number of questions about him or herself. These questions are based on the characteristics that are found to have a modifying influence on the usability of the e-learning system (as explained and illustrated in Figures 1 and 2). The answers to these questions will be combined with the personalisation rules to create a personalised interface that maximises the usability of the e-learning system for that particular user (as shown in Figure 3).

Personalisation rules can be established based on the database of the relationship between user characteristics and their preferred design features. An example of a personalisation rule could be: "If the user has no prior experience with the Internet, then a simplified version of the interface should be used".

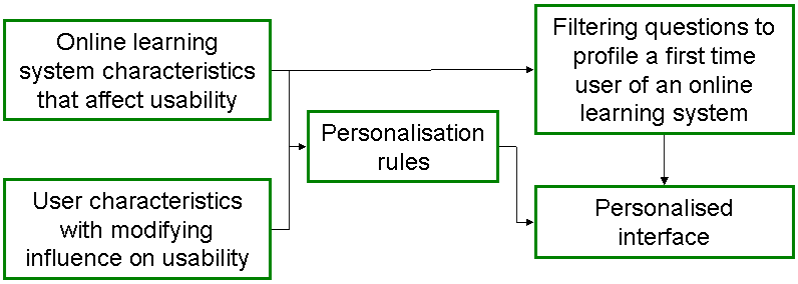

Figure 3: Personalising the E-learning System Interface

Conclusion

The study is currently underway and its results will be valuable for four reasons. First, it will provide usability factors for e-learning system usability evaluation that are relevant and meaningful from the learners' perspectives. These factors can be modified and/or expanded upon for use in other e-learning system usability evaluation approaches that may be developed in the future. Second, the heuristics proposed in the study are customisable for different types of learners and e-learning system. Third, the methodology will provide guidelines to formative usability evaluation specifically developed for e-learning system. Fourth, the results can be used towards the development of personalised interface for individual learners.

References

Bonk, C. J. 2000, *Online Teaching in an Online World*, Bloomington. IN: CourseShare.com.

Elissavet, G. and Economides. 2003, A. A., 'An Evaluation Instrument for Hypermedia Courseware.' *Educational Technology & Society,* vol. 6(2), 31-44.

Gerhardt-Powals, J. 1996, 'Cognitive engineering principles for enhancing human-computer performance,' *International Journal of Human-Computer Interaction,* vol. 8, no. 2, 189-211.

Ghaoui, C. 2003, *Usability Evaluation of E-learning Programs*, IDEA Publishing. Available: http://www.idea-group.com/books/details.asp?id=4008, Accessed 14/8/2005

Govindasamy, T. 2002, 'Successful implementation of e-learning: Pedagogical considerations', *Internet and Higher Education,* vol. 4, 287-299.

Grani, A., Glavini, V., and Stankov, S. 2004, 'Usability Evaluation Methodology for Web-based Educational Systems', *8th ERCIM Workshop: User Interfaces for All*, Vienna, Austria.

Hofstede, G. 1986, 'Cultural Differences in Teaching and Learning', *International Journal of Intercultural Relations,* vol. 10, 301-320.

Kennedy, G., Petrovic, T., and Keppell, M. 1998, 'The Development of Multimedia Evaluation Criteria and a Program of Evaluation for Computer Aided Learning', in *ASCILITE '98,*

Kirakowski, J., Claridge, N., and Whitehand, R. 1998, 'Human Centered Measures of Success in Web Site Design', *The 4th Conference on Human Factors and the Web*, AT&T Lab, 24-27

Koohang, A. 2004a, 'A Study of Users' Perceptions Towards E-Learning Courseware Usability', *International Journal of E-learning*, April-June.

Koohang, A. 2004b, 'A Study of Users' Perceptions Toward E-Learning Courseware Usability', *International Journal on E-Learning,* vol. 3, no. 2, 10-17.

Kukulska-Hulme, A. and Shield, L. 2004, 'Usability and Pedagogical Design: are Language Learning Websites Special?' in *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004*, AACE, Lugano, Switzerland, 4235-4242

Najjar, L. J. 2001, 'Principles of educational multimedia user interface design', in RW Swezey & DH Andrews (eds.), *Readings in training and simulation: A 30-year perspective*, Human Factors and Ergonomics Society, Santa Monica, CA.

Nielsen, J. 1993, *Usability Engineering*, Academic Press.

Nielsen, J. and Molich, R. 1990, 'Heuristic Evaluation of User Interfaces', in *ACM Human Factors in Computing Systems CHI'90*, 249-256.

Nielsen, J. and Philips, V. 1993, 'Estimating the relative Usability of Two Interfaces: Heuristic, Formal and Empirical Methods Compared', in *ACM/IFIP Human Factors in Computing Systems INTERCHI'93*, 214-221.

Nokelainen, P. 2004a, 'Conceptual Definition of the Technical and Pedagogical Usability Criteria for Digital Learning Material', in *World Conference on Educational Multimedia, Hypermedia and Telecommunications 2004*, AACE, Lugano, Switzerland, 4249-4254.

Nokelainen, P., 2004b, 'Designing an Evaluation Tool for Digital Learning Materials', in *Society for Information Technology and Teacher Education International Conference 2004*, AACE, Atlanta, GA, USA, 1810-1817.

Nokelainen, P. 2005, 'The technical and pedagogical usability criteria for digital learning material', in *World Conference on Educational Multimedia, Hypermedia and Telecommunications*, AACE, Montreal, Canada, 1011-1016.

Reeves, T. 1997, *Evaluating What Really Matters in Computer-Based Education*, Education,1997, Available: http://www.educationau.edu.au/archives/cp/reeves.html, Accessed 14/8/2004.

Reeves, T, Benson, L, Elliott, D, Grant, M, Holschuh, D, Kim, B, Kim, H, Lauber, E, and Loh, S. 2002, 'Usability and Instructional Design Heuristics for E-Learning Evaluation', World Conference on Educational Multimedia, Hypermedia and Telecommunications, 1615-1621.

Rentroia-Bonito, M., Armando, J., and Jorge, P. 2003, 'An Integrated Courseware Usability Evaluation Method', in *Knowledge-Based Intelligent Information and Engineering Systems, 7th International Conference*, eds. V Palade, R Howlett & L Jain, Springer, Oxford, UK, pp. 208-214.

Shackel, B. 1981, 'The concept of usability', in *IBM Software and Information Usability symposium*, Poughkeepsie.

Silius, K, Tervakari, A, and Pohjolainen, S. 2003, 'A Multidisciplinary Tool for the Evaluation of Usability, Pedagogical Usability, Accessibility and Informational Quality of Web-based Courses'. Available: http://www.virtuaaliy liopisto.pdf, Accessed 15/8/2004.

Triacca, L., Bolchini, D., Botturi, L., and Iversini, A, *MiLE: Systematic Usability Evaluation for E-learning Web Applications*, AACE, 2004. Available: http://www.aace.org/dl/files/ed.pdf, Accessed 15/8/2004.

Turk, A. 2001, 'Towards Congingent Usability Evaluation of WWW Sites', in Proceedings of OZCHI 2001, Perth, Australia. 161-167.

Webster, R. 2002, Metacognition and the Autonomous Learner: Student Reflections on Cognitive Profiles and Learning Environment Development, Edith Cowan University, Perth, Australia. Available: http://www.csd.uwa.edu.au/iced2002/ publication/Ray_Webster.pdf, Accessed 09/8/2004.